Creationism and Evolutionary Biology

Creationism and Evolutionary Biology – Science or Pseudo-Science?

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1. **Introduction**

When speaking of creationism, it's important not to be too sweeping. There's a wide variety of creationist beliefs, and it might be more accurate to speak of creationism*s*, as Ronald Numbers demonstrates in his magisterial *The Creationists*. One thing can be said for certain: creationism is a *religious* position, held by many Christians and Muslims worldwide. This chapter focuses especially on the most distinctive kind of creationism, Christian young-earth creationism (YEC), which tends to reject biological evolution wholesale, and to maintain that the earth is only a matter of several thousands of years old, perhaps 6,000. Notable organisations which promote this kind of YEC maintain a high public profile—Answers in Genesis, the Institute for Creation Research, and the Creation Research Society—catering for many millions of adherents in the USA and worldwide.

At first sight, the debate between YEC and evolutionary biology tugs at the heart of what it means to 'do science'. Both sides claim to be 'scientific'—with 'creation science', 'scientific creationism', and 'flood geology' being prominent examples on the creationist side—and both sides accuse the other of being 'un-scientific', or in other words, of being a 'pseudo-science' at best. There's a strong argument, however, for saying that this isn't principally a debate about how science should be done, but about from where we derive our philosophical and theological authority to make claims about the world. This is exactly the stance that we shall adopt in this chapter.

While mainstream evolutionary biologists are committed to a process of observation, hypothesising, and testing strictly within the confines of the natural world, YEC introduces a transcendent source of truth (the Bible) which trumps all others. The former group, like all natural scientists, derive their authority from the epistemological assumption known as **methodological naturalism**, but YEC further insists upon two supernaturally-caused events—creation and flood—that change the whole picture. The upshot for YEC is that the *revelation* of Christian Scripture takes precedence over all ***empirical*** research on the origin and development of life, along with the age of the earth. If that research isn't consistent with a literalistic reading of Scripture, then the research is either modified until it is, or rejected outright. There's a sense then, that the endless controversies between creation and evolution over the interpretation of **empirical** evidence completely miss the point, because the issues at stake are actually **metaphysical**.

This chapter will attempt to explain the state of play here by charting the historical evolution of YEC and its strategies, before presenting an overview of evolutionary science for comparison.

2. The creation of creationism

a. Seventeenth-century science into twentieth-century literalism

One of the supreme ironies of the creation-evolution debate is that YEC is a relatively recent phenomenon, only gaining widespread momentum in the twentieth century. YEC draws inspiration for its biblical **literalism** not from long-standing Christian tradition, but from a key phase in the history of science. Two linked developments in the seventeenth century are important here. First, by combining the Protestant Reformation's insistence upon the comprehensive perspicacity of the Bible with the newly-emerging empiricism of the natural sciences, a number of thinkers began to treat biblical texts at face value as a source of data about the natural world, much like data from other, non-scriptural, sources. Second, the age of the earth, and an account of its physical history became of special interest. The most celebrated attempt to date the earth was that of Archbishop James Ussher, who in 1648 made use of biblical genealogies (e.g. Gen.5), ancient near eastern texts, and astronomical results to calculate that creation had occurred on Sunday evening, 23 Oct 4004 BCE, and the flood on Sunday 7 December 2349 BCE. In the same way, early accounts of the physical history of the earth took the biblical stories of creation and flood as providing reliable descriptions of what must have happened. Thomas Burnet's *Sacred Theory of the Earth* (1684, 1690) is notable for treating the biblical flood story (Gen.6-9), not in terms of divine action, but in naturalistic terms. In this way, Burnet explained the form which the earth has today, including the shape of its continents. Not only did Burnet set a trend in geological thinking for the next century and a half (which saw the biblical flood as decisive in shaping the earth we see now), his model is essentially identical to that of contemporary YEC, as put forward in the seminal YEC text, *The Genesis Flood* (authored by John Whitcomb and Henry Morris, and published in 1961). In Burnet's model, the pre-flood earth was totally smooth, but contained great underground cavities of water ('the fountains of the great deep'; Gen.7:11). The flood was caused by these cavities being broken up, and when the waters had subsided afterwards, the present shape of the seas and continents was left. While this model flies completely in the face of mainstream geology today, thanks to Whitcomb and Morris it's adhered to by millions of creationists worldwide.

In between the seventeenth and twentieth centuries, the scientific understanding of the earth and its lifeforms advanced at a whirlwind pace. By the mid-nineteenth century, developments in geology, palaeontology, and biology were indicating that the earth was very old indeed, and that life had evolved over millions of years. These developments were not especially troubling, however, for many conservative Christians, who had found ways of harmonising the new science with the Bible. When faced with a biblical text (Gen.1) which appears to insist that the physical universe was created in six days, many nineteenth-century Christians took refuge in the day-age theory (where each Genesis 'day' was read as figurative of a much longer scientific period of perhaps millions of years), or the gap theory (where an immense time gap was understood to have occurred between God's creation of the universe in Gen.1:1, and the six days described from v.3 onwards). These 'old-earth creationist' strategies, however, fell out of favour with many twentieth century Americans who, faced with new social pressures around what should be taught in high schools, preferred to adopt the most radical alternative to the mainstream scientific picture, that of YEC.

The infamous 'Scopes trial' of 1925 was a watershed. Here, the school teacher, John Scopes, was prosecuted by the state of Tennessee for teaching evolution in defiance of a state law prohibiting it. The trial became a showcase for the creation-evolution debate, with the culpability of Scopes himself of less importance than the question of whether the Bible or modern science should take precedence in teaching about origins. The court proceedings were wide-ranging, concerning not so much the interpretation of the science, but the authority and interpretation of Scripture, and the wider impact upon ethical and political questions. In the event, the court found Scopes guilty, which had the effect of legitimating anti-evolutionary teaching for some time. This was by no means the end of the matter though, and the debate started so publicly by the Scopes trial has ever since pitched two opposing worldviews against each other, with fundamentalist Christianity on the one side, and modernity (as represented by evolutionary science) on the other.

b. 'True science'?

As Edward Davis's article, 'Science Falsely So Called', suggests, the context of the Scopes trial was the growth of fundamentalist Christianity in American society, led by figures such as William Jennings Bryan, one of the main players in the trial. This movement was attempting to establish its conservative brand of Christianity as an intellectual position in its own right against what were seen to be liberalising tendencies based on scientific naturalism, especially German biblical criticism and Darwinism. The fundamentalist argument was that these tendencies were examples of a false science, which steadfastly refused to countenance miracles and supernaturalism. True science, on the other hand, would be open-minded about such things, and crucially would support a literal interpretation of the Genesis creation stories.

But this 'true science' did not reach its definitive formulation until 1961, when Whitcomb and Morris published their *The Genesis Flood*, ensuring that YEC would thereafter be a statement about the significance of Noah's flood as much as a statement about the age of the earth and the failings of evolutionary science. It's no exaggeration to say that this single book has done more to influence the shape of YEC as we know it now than any other. Effectively re-packaging the earlier ideas of Seventh-day Adventist, George McReady Price (1870-1963) along with the far earlier ideas of Ussher and Burnet (but with barely a nod to any of them), this book made the case that the biblical flood provided a catastrophic and divinely-caused alternative to the naturalistic paradigms provided by mainstream geology and palaeontology. As with the earlier fundamentalists, Whitcomb and Morris see this as a matter of true science (their own) against false science (i.e. the mainstream, especially evolution), and for similar reasons. The Bible must be held as completely trustworthy in describing the two divinely-caused events of creation and flood—the biblical flood is a witness and a warning, they believe, and to doubt this is to doubt God's power to save human souls—which means that true science must begin with the revelation of Scripture, and must not moderate it through human philosophies such as evolution. Therefore, human beings, like all other life, were created by God in the (literal) six days of the initial creation, before the flood swept them away (except for what was preserved on the Ark). This much was a literal re-assertion of the biblical text, like the earlier fundamentalists. But unlike the earlier fundamentalists, Whitcomb and Morris engage extensively with geology and palaeontology, and much of *The Genesis Flood* gives a re-interpretation of geological evidence in order to support their view that the flood was a universal cataclysm, and the earth is very young.

It's not our purpose to assess Whitcomb and Morris's arguments in detail here: many others such as Montgomery have done this to great effect, illustrating that Whitcomb and Morris treat the relevant science in a highly-selective way, the better for them to twist it into their version of Burnet's seventeenth-century model of the earth (and such is the force of their rhetoric that it comes over as highly plausible to those Christians who have little knowledge of mainstream geology and evolutionary biology). What we do want to highlight however, is the calls which creationists such as Whitcomb and Morris make on the philosophy of science. Invoking Francis Bacon's (1561-1626) idea that science is principally inductive—making generalised inferences from many direct observations—creationists frequently claim that historical sciences such as palaeontology and evolutionary biology can't be scientific because they can't make direct observations of what actually happened in the past. Instead, the best that such subjects can do is to make untestable and hypothetical speculations, goes the argument. It's interesting to note that Darwin himself faced this accusation over *Origin of Species*. The fact that Darwin and his successors were not deterred, however, but slowly built up the enormous edifice of evolutionary science we know today, indicates two things: first, that **empirical** science is more sophisticated than Baconian **induction** might suggest, and second, that if the creationists' 'true science' is strictly Baconian, then it can bear only a passing resemblance to the natural sciences of today. In short, there are good reasons for judging YEC to be stuck in a pre-nineteenth century view of science, both in method and content.

In order to take this point further, we now present a brief overview of evolutionary biology as it currently stands.

3. Evolutionary science

a. The concept of evolution

Dobzhansky famously wrote that 'nothing in biology makes sense except in the light of evolution'. Evolution is the underlying process that gave rise to the prodigious variety of living organisms on earth (biodiversity), including ourselves. It has generated countless new species during the history of life, of which more than 99% are now extinct. Each species is adapted to its local environment (ecological niche), but changes in climate, geography or biotic factors (other organisms) alter that environment over varying time-scales, causing extinction or providing opportunities to diversify into new, better adapted species (speciation). Five mass extinction events have punctuated earth's history – the most recent wiping out dinosaurs ca.66 million years ago (Ma); there's little doubt that a sixth has been set in motion by human-induced climate change.

Current evolutionary ideas stem principally from Darwin, notably his *Origin of Species*. Evolution can be summarised as 'descent with modification', but this phrase requires unpacking. Animals or plants normally give rise to similar offspring, despite minor variations. The so-called neo-Darwinian synthesis combines Darwin's insights with those of genetics, stemming from Mendel's contemporaneous work on the inheritance of traits. 'Descent' in multicellular organisms usually involves two sets of genetic information (DNA), derived respectively from the father and mother. This diploid genome comprises long sequences of DNA (chromosomes) which include the genes – each specifying one or more proteins that contribute to characteristics of the offspring. Variant versions of the same gene (alleles) often differ in function to a greater or lesser extent. However, protein-coding genes comprise only a small fraction of the total DNA genome; much of the rest has regulatory functions that aren't yet fully understood. Some genes are duplicated, and extra copies may become redundant (pseudogenes) or specialised for new functions. Darwin envisaged a 'tree of life' whose branches diverge into new species 'twigs': the fact that all living things use DNA as their genetic material, with similar mechanisms for translating that information via RNA into proteins, implies that they have diversified from a common ancestor.

b.Genetic variation

Importantly, however, the genes transmitted to offspring aren't invariant. Beyond the mixing of parental genes that occurs during gamete development (animal sperm or eggs; plant pollen or ova), there are also random changes in the DNA sequence resulting from genetic mutation, caused by radiation or chemical damage. Usually such damage is accurately restored by DNA repair to the original sequence, but sometimes this fails, resulting in a point mutation. Such changes can occur within a gene or in its neighbouring regulatory regions, though sometimes larger genetic changes arise. DNA sequence changes within a protein-coding gene commonly alter the encoded protein. Again, the outcomes vary considerably, ranging from deleterious effects on function (human genetic diseases such as sickle-cell anaemia), through marginal or zero ('neutral') effects, to functional improvements – enabling that individual to reproduce more successfully in a changing environment or different ecological niche. Such beneficial mutations are admittedly rare, but can spread rapidly within a population provided there is sufficient selection pressure.

c. Selection

If space and food are abundant, populations of organisms will expand geometrically, as first noted by Malthus. When resources become limiting, this is no longer possible. Darwin's key driver for evolution is *natural selection*; essentially, a given set of environmental conditions (mainly biotic factors such as food supply, predation or disease) promotes the reproductive success of individuals carrying certain favourable mutations, but also selects against other (less favourable) mutations. Selection can be applied artificially by humans, as in selective breeding of crop plants, livestock animals or pets, generating the huge variety of modern breeds within the short time-scale of human history. Inadvertent artificial selection is also well documented, notably the ability of pests to evolve pesticide resistance. The distinction between favourable and unfavourable mutations is context-dependent rather than absolute. The sickle-cell mutation is common in West African populations, even though full-blown sickle-cell disease (individuals with two mutated genes) is usually fatal. However, carriers of the sickle-cell trait (one normal and one mutated gene) aren't only healthy but have increased resistance to malaria. The combined effect of all genes on an individual's reproductive success (reflected in progeny numbers) is described by the aggregate term *fitness*; this is what is implied by 'survival of the fittest'.

Artificial selection has produced significant changes within very short time-scales compared to the age of the earth (4.5 billion years) and of life on its surface (3.7 billion years). These timings are in turn based on the geological record, using best estimates for the ages of different rock strata derived from invariant rates of isotope decay. It's therefore plausible that geological time-spans are sufficient to allow the diversification of life on earth through evolution by natural selection.

d. Species

The taxonomic system used today originated with the Swedish naturalist Linnaeus, who employed morphological criteria to classify animals and plants. Each distinct type of organism has a Latin binomial classification – the first name denoting the genus or group, and the second the species. Thus the genus *Homo* includes the only extant member, *Homo sapiens*, plus extinct species such as *H. erectus*, *H. neanderthalensis* and *H. floresiensis*. Genera are grouped into families (e.g. orchids – Orchidaceae; grasses – Poaceae), and families into orders (beetles – Coleoptera; bees etc – Hymenoptera). Orders are further grouped together into classes (Hexapoda in this case), and these in turn into phyla sharing a common body-plan. The phylum Arthropoda includes insects, arachnids (spiders etc), crustaceans and myriapods. DNA sequencing provides independent insights into the underlying genetic relationships between organisms, largely confirming an evolutionary basis for Linnaean classification, but also providing examples of deep genetic differences between superficially similar organisms, and unexpectedly close links between dissimilar-looking species. Since DNA mutation occurs at a relatively constant rate, one can infer the timing of branchpoints when species diverged by constructing phylogenetic trees based on DNA sequence data.

New species often arise through reproductive isolation, e.g. when organisms colonise an island. In the Canary Isles, for instance, certain plant genera contain numerous species that are far more diverse than their continental relatives; examples include buglosses (*Echium*) and spurges (*Euphorbia*). This results from adaptive radiation, whereby the progeny of founder individuals adapt to a variety of available ecological niches. Several Canarian *Euphorbia* species have evolved cactus-like forms adapted to drought, even though true cacti belong to an unrelated family. Both arose by convergent evolution, whereby similar adaptations (affording an optimal design solution) have arisen independently in different groups that don't share a common ancestor with the same trait. Box-camera eyes in vertebrates and cephalopods provide another classic example of convergence. Related species are usually unable to interbreed, though in some families (e.g. orchids) hybridisation is common, suggesting that reproductive barriers aren't always erected during speciation.

e. Gradualism versus punctuated equilibrium

There's a long-standing debate over the rate of evolutionary change. One of the main difficulties in discerning this regards the incompleteness of the fossil record, with soft-bodied organisms especially poorly represented. Even for species whose hard parts are readily preserved (molluscan shells, vertebrate bones), there are gaps and anomalies in the fossil sequence, though occasionally a near-complete series of intermediates links early with modern forms (e.g. elephants). These exemplify 'gradualism', denoting slow progressive evolution over time.

In apparent contrast to gradualism stands the theory of punctuated equilibria, which postulates long periods of stasis punctuated by periods of very rapid evolutionary change. This may be something of an optical illusion: beyond the acknowledged incompleteness of the fossil record, periods of rapid evolution often follow mass extinction events, when surviving species diversify to fill environmental niches occupied previously by now-extinct organisms. Long periods of gradual evolutionary change are thus punctuated by bursts of rapid adaptive radiation that are brief in geological terms, but still span millions of years.

Moreover, many genes operate in tightly controlled networks, such that mutations in a regulatory 'upstream' gene can have multiple pleiotropic effects on the 'downstream' genes whose expression it controls. This is particularly true of the so-called 'master genes' that direct animal and plant development – such as the homeotic *Hox* genes governing regional identity in many animals, or heterochronic genes specifying developmental timing. Mutations in these genes could lead to radical changes in body plan or life history, potentially contributing to rapid evolutionary change.

f. The origin of life

Descent by modification implies a common ancestor, an organism that must have emerged during the first billion years of earth's existence. Presumably this organism already used DNA as its genetic material, and probably resembled the *Archaebacteria* that survive today in extreme environments such as hydrothermal vents and hotsprings. Inferred conditions on the young earth's surface were probably conducive to spontaneous formation of organic molecules providing vital building blocks for life. However, it's a huge leap from puddles of primaeval soup containing the requisite ingredients to a living cell capable of reproducing itself and passing on its DNA. Possibly the earliest life-forms were based on RNA, which can act both as genetic material (RNA genome in retroviruses) and also carry out many protein-like catalytic functions (ribozymes). But RNA-based life forms have left no descendants today, and other possibilities remain open. Recent discoveries of planets orbiting other stars raise the possibility of life evolving elsewhere in the universe. But maybe ours is a rare type of planet, unusually favourable for the evolution of life based on the unique chemical properties of carbon in a watery environment.

For much of earth's history, life was microbial, leaving fossilised mats and three-dimensional stromatolites generated by unicellular bacteria (prokaryotes). Higher organisms – fungi, plants or animals – are mostly multicellular, allowing different cells to specialise for particular functions (differentiation), such as animal nerves or muscles. This became possible thanks to the emergence of novel eukaryotic cells which are essentially combinations of two or more prokaryotic cells, one living symbiotically within another – Margulis' endosymbiont hypothesis. At least two intracellular organelles within plant cells originated in this way: the energy-producing mitochondria and photosynthetic chloroplasts, each derived from a different prokaryotic ancestor. Animal cells possess mitochondria only, but the high efficiency of their energy production (using oxygen) is essential for active lifestyles. Thus evolution can involve elements of cooperation and networking; it's not all 'red in tooth and claw'.

g. The origin of animals

During the Ediacaran era (635-542 Ma), the oceans were inhabited by strange organisms that lack obvious affinities with familiar animals or plants. Within a relatively brief period, termed the 'Cambrian explosion' (starting ca.542 Ma), these biota virtually disappeared, and were replaced by animals belonging to modern phyla – including arthropods, sponges, comb jellies, marine worms and chordates. These assignments are supported by exceptionally well-preserved Cambrian fossils, including traces of soft body parts. However, many of these fossils remain enigmatic, to say the least, because their anatomies seem unlike modern animal groups.

For Gould, these anomalies represent novel body plans that did not survive the ravages of natural selection and hence became extinct. Provocatively, he claims that if the ‘tape of evolution’ were rerun from the Cambrian, we might find ourselves today in a world dominated by a very different selection of organisms. Gould emphasises the randomness of survival in the evolutionary lottery, scotching any notion of progress from ‘lower’ to ‘higher’ forms, culminating in humans.

However, Conway Morris interprets these fossils very differently, as intermediates or ancestors in the appearance of new animal groups. He focuses particularly on convergent evolution, adducing numerous examples of this process and arguing that only certain design ‘solutions’ actually work to enhance fitness – hence these adaptations recur repeatedly in independent lineages. The example of box-camera eyes was cited earlier, likewise the convergent adaptations against drought adopted by American cacti and some Canarian *Euphorbia*s. Extrapolating speculatively from this, intelligent bipedal life may be a predictable outcome from prolonged evolution in a benign planetary environment.

One suggested compromise is that these now-extinct Cambrian animals belonged to major class-level groups (as distinct from modern groups as insects are from crustaceans), but did not represent completely different body-plans corresponding to vanished phyla.

h. Evolution of behaviour

Evolution moulds not only physical attributes but also patterns of animal behaviour. Because ‘fitness’ is measured by success in transmitting one’s genes to offspring, reproductive traits have been subjected to intense sexual selection in one or both sexes, affecting structures and behaviours involved in courtship and mating. The elaborate tail feathers of male peacocks afford one obvious example, as do the heavy antlers of many male deer. Since exaggerated physical or behavioural attributes are interpreted as indicators of a sexual partner’s fitness, these can become runaway evolutionary trends.

Plant pollination by specific insects creates selection pressures for both species, leading e.g. to deeper flowers and longer mouthparts – a trend which may be carried to astonishing extremes. The 30 cm-long spur of the Madagascan Comet Orchid requires a hawkmoth pollinator whose similarly long proboscis allows it to feed on nectar at the base of the spur. There is, however, a cost: this plant cannot be fertilised by other insects, and both organisms are mutually dependent on one another. They have co-evolved, and if either became extinct, the other would be doomed. Innumerable other examples of mutual dependency between organisms are known; often (though not always) there is clear benefit to both in such associations.

In parasitism, the benefits seem entirely one-sided. Parasites gain nutrients and a sheltered environment (though host immune responses attempt to combat the invader), while hosts suffer mild to debilitating disease. Levels of parasitism affect patterns of behaviour such as host dominance hierarchies and reproductive success. Here, an arms-race is in progress: as the host evolves new immune strategies to control the parasite, natural selection encourages the latter to evolve better ways of countering or evading them.

i. Evolution of human culture

Humans share more than 98% of their DNA with chimpanzees, and rather less with other great apes. Patterns of animal behaviour are often instinctive rather than learned, suggesting they're 'hard-wired' in the nervous system by that animal's genes. That said, most behaviours can be modified by learning through experience. Other behaviours are learned from parents or group members, resulting in 'cultural variants' particular to local groupings. Humans take this to extremes: diverse cultures have evolved rapidly over time, as documented in both written and archaeological records.

4. Creation, evolution, and science

We're now in a position to answer the question in our title. The precise definition of 'science' is notoriously difficult to pin down, but the overview in the previous section has hopefully demonstrated that evolutionary science qualifies on many counts, not least for its amazing explanatory scope across a huge range of biological questions, for its incorporation of many diverse kinds of scientific enquiry within itself (including branches of physics and chemistry which no one disputes as 'science'), and for its ability to spawn fertile new research programmes. The accusation of YEC, that evolutionary theory isn't scientific, seems churlish (to put it mildly) in light of this phenomenal success. It's true that evolutionary history is not accessible by means of direct experimentation in the laboratory, but this doesn't preclude a basic empiricism in historical sciences like evolutionary biology, geology and astronomy: they proceed, just like the other natural sciences, by means of a cyclical process of observation, hypothesising, searching for more evidence, and revision/rejection of the initial hypothesis.

In comparison, YEC fails dismally as an **empirical** science. Indeed, there's a strong case for suggesting that YEC doesn't even qualify as a 'pseudo-science' on this score. YEC makes claims (hypotheses) that are open to empirical testing—principally the young age of the earth, and the worldwide extent and cataclysmic character of Noah's flood—but these have been shown to be entirely false by the mainstream **empirical** sciences countless times, *and yet YEC persists in making these claims*. In other words, YEC is such a failure as a science (and even a pseudo-science) that it can't reasonably be claimed to be one. YEC takes its certainty not from any body of knowledge about the natural world but from a transcendent source (the Bible), upon which it will not budge a single inch.

It's therefore our argument that evolution is certainly scientific, but creationism (in the form of YEC) is neither scientific nor pseudo-scientific; it's **metaphysical**.

CHAPTER SUMMARY

- There are various creationisms, but young-earth creationism (YEC) in particular has persistently challenged the scientific claims and status of evolutionary biology.
- YEC arose in the twentieth-century, arguably as a conservative religious backlash against progressive modernism. YEC offers its own distinctive 'science', which posits a young earth, and a worldwide flood which shaped the earth's present geology and fossil record mere thousands of years ago.
- Both sides of the creation-evolution debate accuse the other of not being scientific, although their definitions of science seem to be widely divergent. While the claims of

evolutionary biology are based on painstaking observation and experimentation of the natural world by thousands of individuals working across a wide spectrum of life sciences, those of YEC must conform above all to a literalistic reading of the Bible, as the primary source of evidence concerning origins.

- One particular bone of contention concerns the question of whether study of the past can be truly scientific, since it can't be observed in the laboratory. YEC argues that the evolutionary history of life is an un-scientific hypothesis which rejects the pre-eminent status of the Bible as a source of both scientific and religious truth.
- But mainstream evolutionary science is committed to **methodological naturalism**, and does not rely on transcendent sources of truth. Instead, sophisticated methods of study have been developed to investigate the history of life in **empirical** terms. The starting assumptions of evolutionary biology are quite different to YEC, and while the former's fall squarely within those of mainstream science, YEC represents a totally different worldview which cannot be described as 'scientific' in any conventional sense.

STUDY QUESTIONS

1. How would you distinguish science from 'pseudo-science'?
2. The ancient scriptures of Christianity, Judaism and Islam show evidence of ancient cosmologies and ancient scientific ideas. Should religious believers take account of modern scientific views when reading these texts?
3. How would you characterise the hermeneutical approach of YEC to the biblical text? What are its strengths and weaknesses?
4. Describe the essential character of those sciences that deal with the natural world of the past, in relation to the sciences that proceed by direct, laboratory-based work (e.g. chemistry)? Are the differences important enough to mean that the former sciences should always be qualified in some way (e.g. as 'historical sciences').
5. How do the so-called 'historical sciences' relate to the study of human history (i.e. 'history')?
6. How important is Baconian induction in the natural sciences today?
7. How important is Darwin's natural selection as an evolutionary mechanism in modern evolutionary biology?

INTRODUCTORY READINGS

Conway Morris, Simon (2003) *Life's solution: inevitable humans in a lonely universe* (Cambridge: Cambridge University Press).

Gould, Stephen Jay (1989) *Wonderful Life: the Burgess shale and the nature of history* (Harmondsworth: Penguin Books) [This and the Conway Morris title should be read alongside each other as charting one of the most active debates in science today].

Darwin, Charles (1859) *On the Origin of Species* (London: John Murray).

Montgomery, David R. (2012) *The Rocks Don't Lie: A Geologist Investigates Noah's Flood* (New York: W.W. Norton & Co). [An accessible discussion of the way that the biblical flood story shaped the development of the modern science of geology, and of YEC].

ADVANCED READINGS

Davis, Edward B. (2012) 'Science Falsely So Called: Fundamentalism and Science.' In *The Blackwell Companion to Science and Christianity*, ed. J. Stump and A. Padgett (Chichester: Blackwell), 48-60 [A useful account of the early years of fundamentalist Christianity in America].

Eldredge, Niles and Stephen Jay Gould (1972) 'Punctuated equilibria: An alternative to phyletic gradualism.' In *Models in Paleobiology*, ed. T.J.M. Schopf (San Francisco: Freeman Cooper), 82-115 [The landmark paper which introduced the idea of punctuated equilibrium into evolution].

McCalla, Arthur (2013) *The Creationist Debate: The Encounter between the Bible and the Historical Mind* (New York, London: Bloomsbury) [A highly-penetrating overview of the origins and significance of creationisms].

Numbers, Ronald L. (2006) *The Creationists: From Scientific Creationism to Intelligent Design* (Cambridge (MA), London: Harvard University Press) [A seminal classic, taking a critical but sympathetic view of YEC].

Whitcomb, John C. and Henry M. Morris (1961) *The Genesis Flood: The Biblical Record and Its Scientific Implications* (Phillipsburg, NJ: Presbyterian & Reformed) [The founding text of YEC].

FREE INTERNET RESOURCES

Answers in Genesis, answersingenesis.org [Perhaps the most active of all YEC organisations in the Christian world currently].

BioLogos, www.biologos.org [An evangelical Christian organisation which challenges YEC, and is dedicated to introducing believers to mainstream scientific accounts of origins].

Harun Yahya, www.harunyahya.com [The highly-influential Muslim young-earth creationist].

Reasons to Believe, www.reasons.org [The prominent old-earth creationist organisation, led by astronomer, Dr Hugh Ross].

GLOSSARY

Induction: Inferring a general principle from the result of many observations. An inductive statement is only as certain as the strength of the data, unlike deduction, which invokes general principles to draw a certain conclusion.

Literalism: In creationism, the belief that the Bible contains the actual words of God, and should therefore be taken as the literal truth, whatever the subject matter.

Methodological naturalism: the working hypothesis at the heart of all natural sciences, that the natural world can be explained entirely on its own terms, without recourse to the supernatural.